

SEDIMENTATION AND GEORGIA'S FISHES: AN ANALYSIS OF EXISTING INFORMATION AND FUTURE RESEARCH

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Abstract. Excessive sedimentation and high levels of turbidity threaten the native fish species of Georgia by destroying habitat and by impairing fish feeding and spawning. To propose water quality standards for suspended sediments that would be protective of Georgia's diverse freshwater fish fauna (283 spp.), we have searched existing records of suspended sediment concentrations (measured as turbidity in NTUs) and fish collections taken throughout rivers and streams in Northern Georgia above the fall line. The study revealed that adequate measures of suspended sediment are lacking in areas of high fish diversity, and therefore field work in representative basins is needed to find relationships between suspended sediments and fish diversity. Research is currently being done in the Etowah River system of Northern Georgia to further understand the effects of excessive sedimentation on native fish communities.

INTRODUCTION

Sedimentation is the single largest contributor to pollution of our nation's rivers and streams (EPA, 1987). In a survey of U.S. waters, excessive siltation from erosion occurred in 46% of all streams and was considered the most important factor limiting usable fish habitat (Judy et al., 1984). Because of human population growth and the associated urban development and agricultural land use that has occurred since this survey was published, the percentage is most likely higher today, particularly in the South where population growth has been so rapid in the past decade (Bachtel and Boatright, 1994). Despite a rapid reduction in the amount of sedimentation since the turn of the century because of reduction in row crop agriculture, human-accelerated sedimentation remains a ubiquitous threat in all southern upland river systems (Burkhead et al., 1995). Human activities accelerating sedimentation rates include urbanization of river corridors, channelization of streams, road construction, and clearcutting of forests (Waters, 1995). Throughout the United States, the annual costs of water-induced soil erosion is approximately 7.4 billion dollars (Pimental

et al., 1995). This estimate, however, does not consider the impacts of sedimentation to aquatic ecosystems and its intangible costs to humans.

The main goal of this project is to examine the relationship between sedimentation and fish diversity in Georgia to better understand the detrimental effects of excess sediment on aquatic systems. This task involves the integration of two separate disciplines in aquatic science - stream ecology and fluvial geomorphology. The ecological science consists of an understanding of the fish species richness in aquatic systems and the associated habitat requirements. The fluvial geomorphological component involves an analysis of sedimentation regimes in different physiographic provinces of Georgia. For this interdisciplinary project, data from both disciplines must be available for analysis. As we have discovered during the course of this research, that condition is rarely met in Georgia.

BACKGROUND

Effects of Sedimentation

Habitat degradation in aquatic systems is often associated with increased levels of sediment deposition. Although erosion and movement of sediment in the downstream direction are natural processes, excessive sedimentation and siltation caused by anthropogenic forces directly effect survival of fishes by reducing spawning and foraging habitat for benthic fish species by filling in the interstitial spaces of loose gravel and cobble substrates (Burkhead, et al., 1995). This blanketing of the stream bottom indirectly affects fish populations by decreasing habitat for aquatic macroinvertebrates which many benthic fishes utilize as a food source. As reviewed by Burkhead et al. (1995), Ellis(1936), and others, substrates blanketed by sediment lose vital habitat niches for macroinvertebrates, causing reductions in faunal and community complexity. These reductions, caused by sedimentation, diminish trophic web complexity and the efficiency of nutrient cycling, thus indirectly

affecting fish populations within the aquatic community. Georgia's unique fish fauna is threatened by habitat degradation from excessive sedimentation and is in need of protection.

The diversity of fishes in Georgia is astounding, with approximately 283 freshwater species (unpublished data). This is a richer fish fauna than most countries, and the only other U.S. states with larger numbers of species than Georgia are Alabama with 306 (Mettee et al, 1996) and Tennessee with between 302 and 319 species (Etnier and Starnes, 1993). There are currently 9 federally threatened or endangered fish species in Georgia, with the 7 of them inhabiting rivers and streams above the fall line.

Turbidity and TSS

The relationship between total suspended solids (TSS) and turbidity, measured in nephelometric turbidity units (NTU), has not been determined. When suspended sediment measurements are taken by the USGS, most values are reported as NTUs although several stations measure only TSS. The preferred regulatory method for measuring the influence of sediment on water quality has been changed from TSS to NTU (Board of Regents' Scientific Panel, 1995). The Panel concluded that turbidity measured in NTUs provides a more effective and cost efficient method of monitoring water quality than measuring TSS in mg/l. The Board of Regents' Scientific Panel recognized that the relationship between turbidity and total suspended solids varies greatly, due to variation in stream power and sediment composition across different physiographic provinces. Because factors converting TSS to NTU have not been determined for a range of watersheds in varying physiographic provinces of Georgia, the panel assumed a 1:1 relationship, which was supported by available data.

A closer inspection of these data reveals some differences in the relationship between NTU and TSS in the three physiographic provinces. Most data points from the Piedmont fall either on or above the 1:1 line, suggesting that NTU overestimates TSS in this province. Given the high clay content of Piedmont soils, it is not surprising that a small mass of suspended sediments could produce a higher turbidity reading. Most data points from the Ridge and Valley and Blue Ridge provinces fall either on or below the 1:1 line, suggesting that NTU underestimates TSS in those provinces.

Existing Data on Sediment and Fishes in Georgia's Rivers

One of the main goals of this project was to find existing information on relationships between fish biodiversity and sedimentation in Georgia's waterways. A search of the current literature completed during deliberations of the Georgia

Erosion and Sedimentation Control Panel, found a lack of predictive relationships for Georgia's fishes after examination of approximately 400 citations spanning a fifty year period. Most of the existing information on the effects of excess sedimentation on fish emphasizes salmonids and other game species. There is little information available on the adverse effects of turbidity and sedimentation on benthic fish species of Georgia, which are often more susceptible to degradation of stream substrate. In the Southern Appalachians, 94% of freshwater fishes are benthic spawners (Burkhead et al., 1995), clearly placing many species at risk to substrate degradation of spawning sites due to increased sedimentation and turbidity.

METHODS

We searched sediment and fish databases to determine if existing information can be used to more firmly establish a relationship between suspended sediment concentrations and fish diversity. We have uncovered several inadequacies in existing sediment information, one of which relates to the available sediment data. The only organization that regularly collects sediment data for many rivers of Georgia is the United States Geological Survey (USGS). Several other organizations, such as the Environmental Protection Agency (EPA), Bureau of Land Management, and the Department of Natural Resources periodically sample rivers for sediment, but this is usually only done for a particular event, such as a construction activity adjacent to a waterway, and the number of data points are minimal. The EPA's STORET database contains some sediment data for Georgia. However, a significant portion of their data is also available through the USGS Water Resources Data for Georgia. Because of difficulties with access and several temporary closings of government agencies this past year, we did not search the STORET database. The USGS sediment data from 1958 to 1994 was thoroughly searched.

We searched 36 years of water quality data and over 20,000 records of fish collections in Georgia. Only 0 - 8% of the sediment sampling stations in four major river basins in this part of the state (Mobile, Apalachicola-Chattahoochee-Flint, Altamaha, and Tennessee) have contemporaneous fish and sediment data (Table 2). We analyzed the existing fish and sediment data by examining the percentage of suspended sediment samples that exceed 25, 50, and 100 NTU and by comparing the feeding and spawning guilds of fishes at sites with different NTU exceedence characteristics. We then used these data to hypothesize suspended sediment regimes that would be protective of the native fish assemblages.

RESULTS

Two systems of the Piedmont physiographic province in the Altamaha Basin, Yellow River and Falling Creek, were analyzed to compare fish species composition and sediment exceedence. Based on museum collections, Yellow River has a more degraded fish species assemblage than Falling Creek. Analysis of existing sediment data from 1982 - 1994 from these two systems also suggest that the Yellow River is more degraded than Falling Creek (Table 1). Based on these fish and sediment data, we hypothesize that in the Piedmont physiographic province, native fishes would be protected if random monthly samples of turbidity never exceed 100 NTU, if less than 5% of random monthly samples exceed 50 NTU, and if less than 20% of random monthly samples exceed 25 NTU.

The Conasauga River in the Ridge and Valley physiographic province was analyzed to compare fish species diversity and turbidity downstream from the GA/TN line to Tilton, GA. Study sites were divided into three areas on the river: the GA/TN stateline, near Dalton, and at Tilton. More than a 50% reduction in sediment-sensitive fish species was revealed in collections from the stateline to Tilton. According to recent fish collection surveys, there are 50, 49, and 38 species present at Stateline, Dalton, and Tilton, respectively. The twelve species not found at Tilton are benthic species that require clean gravel free of fine sediment. Analysis of sediment data from 1982 - 1994 from these sites also showed a degradation in water quality from the stateline to Tilton (Table 1). Based on fish and sediment data from these three sites in the Conasauga River, we hypothesize that in the Ridge and Valley physiographic province, native fishes would be protected if monthly random samples of turbidity never exceed 25 NTU. These more stringent standards appear necessary because of the nature of the sediments in this physiographic province and because of the vulnerability of the imperiled fishes in this region to sedimentation. These hypotheses require field testing.

DISCUSSION

Existing sediment data are inadequate for making comparisons to existing fish collection data for Georgia for several reasons. The first involves the frequency and duration of sediment data collection. Turbidity readings are only taken once a month, and often not for a complete year. Data collection frequency varies from basin to basin, and there are often gaps of several years in the data. Many stations have sediment data for only two years in the past 35 years.

The episodic nature of erosion events results in temporal variations in sediment concentrations that

cannot be characterized by monthly sediment measurements alone. Suspended sediment concentrations fluctuate widely depending on soil composition and precipitation intensity. A measurement taken one time in a 30 day period may not give a true indication of the monthly average turbidity of a stream. Yet monthly samples are the only data available in the existing record.

Another inadequacy with existing sediment data is the lack of sampling in smaller tributaries of river systems, where the deleterious effects of excessive sedimentation are often seen first. Small streams, especially in northern Georgia, harbor diverse assemblages of fishes that are often different from the assemblages in the main stem river. The majority of sediment sampling sites are in the main stem of large rivers or in their major tributaries. In the Chattahoochee River basin, for example, only 10 sediment sites are in smaller streams as opposed to 31 in the main stem and its major tributaries (USGS Water Resources Data, 1957 - 1994). Although intensive sampling of smaller tributaries in river systems may be economically unfeasible, sediment data for smaller streams are needed to identify sources of sediment and to specify baseline conditions for suspended sediments that are compatible with a diverse fish assemblage.

The final and most important problem with existing data for Georgia is the absence of contemporaneous fish and turbidity data at the same site. This problem is illustrated in Table 2. There are a limited number of sites with both fish and sediment data and no individual site has both fish collections and sediment data for a period longer than one year. The average percentage of sites in the basins studied that have sediment and fish data is 17%. Less than 4% of the sites have fish and sediment data for the same year. These low percentages reveal a major problem in finding comparative fish and sediment data for Georgia's waterways.

Because of insufficient long-term comparative data, temporal trends in fish diversity cannot be related to long-term trends in sedimentation regimes. The rivers in the Mobile, Apalachicola-Chattahoochee-Flint, Altamaha, and Tennessee basins have insufficient numbers of fish collections taken at sediment data collection sites to conclusively determine direct effects of sedimentation on fish diversity. In other basins north of the fall line, sediment sampling stations are also in larger rivers and hence we anticipate little concordance between sediment and fish collection sites. The only other basin of substantial size above the fall line is the Savannah; because of the large number of dams on this river, it was not included in this study. Dams present a barrier to fish movement, isolating populations and drainages and confounding interpretation of sediment effects (Moyle and Leidy, 1992).

Table 1: Comparison of numbers of fish species and turbidity exceedence in Georgia's rivers and streams

Drainage Basin	River/stream	Total # of fish species	#(%) of fish species requiring gravel for spawning	% of turbidity measurements exceeding 25 NTU	% of turbidity measurements exceeding 50 NTU	% of turbidity measurements exceeding 100 NTU
Altamaha	Yellow River	5	2 (40%)	36	15	6
Altamaha	Falling Creek	16	9 (56%)	20	4	0
Mobile	Conasauga (Stateline)	50	18 (36%)	0	0	0
Mobile	Conasauga (Dalton)	49	14 (29%)	19	7	3
Mobile	Conasauga (Tilton)	38	6 (16%)	31	13	3

Table 2: Existing data on suspended sediments and fish collections in selected drainages of Georgia

Drainage Basin	# of USGS gages	# of museums searched for fish records	# of sites that have at least one year of sediment data	# of sites that have 10+ years of sediment data	# (%) of sediment sites that have fish collection data	# (%) of sites that have fish and sediment data from the same year
Mobile	60	10	43	21	9 (15%)	2 (3%)
ACF	59	10	49	18	14 (24%)	5 (8%)
Altamaha	50	10	31	16	6 (12%)	2 (4%)
Tennessee	24	10	24	4	4 (17%)	0 (0%)

From this extensive search of existing data, we conclude that adequate measures of suspended sediment are lacking in areas of high fish diversity. Field work in representative watersheds is needed to better understand the relationship between fish diversity and increasing sedimentation/turbidity of Georgia's rivers and streams.

CURRENT AND FUTURE WORK

We propose to continue this analysis of the relationship between sedimentation and Georgia's native fishes by sampling at selected sites in the Etowah River system. The Etowah River and its tributaries in the Mobile Basin of Georgia are under threat of losing their high fish diversity from excessive sedimentation. The upper Etowah (above Allatoona Reservoir) lies squarely in the path of expanding metropolitan Atlanta and is developing rapidly with accelerated rates of sediment deposition occurring as a result. American Rivers, a national conservation organization, recently recognized the Etowah River system as one of the top ten endangered rivers in the U. S. There is scant historical data available on sedimentation in most of the Etowah's tributaries when compared to a large record of fish collections in the area. Research is needed in this river system to understand the

relationship between physical attributes of the river and fish diversity. The Etowah River system is an excellent study area for a comparison of sedimentation and fish biodiversity because of the range of habitats and the high diversity of fishes in the basin. The Etowah River has approximately 89 native species with 12 of these being imperiled, three of which are listed as either threatened or endangered by the U.S. Fish and Wildlife Service. These sensitive species can be used as bio-indicators of stream health and integrity. As habitat degrades, numbers and abundances of sensitive species often tend to decrease (Karr, 1986).

We are currently sampling sediment and fishes at 12 sites in the Etowah River system in the Blue Ridge and Upland Piedmont physiographic provinces in Lumpkin County, Georgia. Sediment loads are estimated using bedload, TSS, and NTU measurements. This 25 mile-long headwater section of the river is the least developed region of the watershed and is the most vulnerable to habitat degradation as development pressures are increasing. This area of the Etowah River system includes both Chattahoochee National Forest as well as private lands. Study sites have been chosen in the upper Etowah River system to represent a range of habitat degradation from minimally impacted streams in undeveloped areas to more disturbed streams in more developed areas. Sampling locations are at five sites

on the mainstem of the Etowah River and in seven second and third order tributaries since these are the streams most likely to be first affected by sedimentation. These smaller order streams are paired by drainage size so that comparisons between sites are more feasible.

CONCLUSIONS

Through field observations and comparisons of historical fish and sediment data, information will be gained that can provide specific guidance to the legislature on what sedimentation standards would be protective of the aquatic life in Georgia's rivers and streams. Georgia has a unique fish fauna that is worthy of protection, and development of regulatory criteria that will protect this resource are needed. The proposed research is essential in linking conservation biology with sustainable development through a better understanding of the interactions between fish and sediments and a reduction of the amount of fine sediments entering Georgia's waterways.

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